AN AJSS An Asian Journal of Soil Science
Volume 11 | Issue 1 | June, 2016 | 103-109 | e ISSN–0976–7231 ■ Visit us : www.researchjournal.co.in

Research Article

DOI : 10.15740/HAS/AJSS/11.1/103-109

Mapping of nutrients status by geographic information system (GIS) in Navagarh block under Janjgir district in Chhattisgarh

■ DEEPIKA DEVDAS , L. K. SRIVASTAVA AND V.N. MISHRA

Received : 29.01.2016; **Revised :** 01.04.2016; **Accepted :** 27.04.2016

MEMBERS OF RESEARCH FORUM:

Corresponding author :
DEEPIKA DEVDAS, Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya,, RAIPUR (C.G.) INDIA
Email: deeps.devdas@gmail.com

Co-authors :
L.K. SRIVASTAVA AND V.N. MISHRA, Department of Soil Science and Agricultural Chemistry, Indira Gandhi Krishi Vishwavidyalaya, RAIPUR (C.G.) INDIA

Summary

A study was conducted to assess available nutrient status of soils of Navagarh block in Chhattisgarh by GIS technique. Grid based surface (0-15 cm) drawn from the farmers' fields were analysed for their fertility status and mapped by geographic information system (GIS) technique from 125 villages of Navagarh block.The soil samples were analyzed for pH, EC, OC, N, P, K, Fe, Mn, Cu, Zn. The soil pH varied from 4.8 to 8.0 (mean 5.93) and indicated that soils were found to be moderately acidic to slightly alkaline in reaction. The electrical conductivity of soil water suspension ranged from 0.04 to 0.98 dS m^{-1} with a mean value of 0.20 dS m^{-1} and all soil samples under normal range (<1.0 dS m^{-1}).The mean value of organic carbon was 0.55 per cent and about 90 per cent soils of this block comes under medium fertility group. The soils were low in available N content. It ranged from 87to 399 kg ha^{-1} with an average of 258 kg ha^{-1}. The status of available phosphorus varied from 1.52 to 29.33 kg ha^{-1} with a mean value of 12.88 kg ha^{-1}. The 96.82 per cent village soil samples from the study area can be classified as low fertility class. Nutrient index values were in low fertility class except 8 villages for N and 44 villages for P comes under medium nutrient index value. The available potassium varied from 88 to 503 kg ha^{-1} with a mean value of 279 kg ha^{-1}.The more than 90 per cent soil samples were classified as medium to high fertility class. The available iron, manganese, copper and zinc content ranged from 0.44 to 91.6 mg kg^{-1} (mean 25.47 mg kg^{-1}), 0.32 to 84.4 mg kg^{-1} (mean 29.90 mg kg^{-1}) and 0.16 to 28.1 mg kg^{-1} (mean 2.56 mg kg^{-1}), 0.02 to 10.84 mg kg^{-1} (mean 1.61 mg kg^{-1}), respectively in soil of Navagarh block. Most of soil samples were found in sufficient levels of Fe, Mn and Cu but 32.21per cent soil samples were deficient in Zn content. Soil nutrient index of overall soils group were found in low fertility class of nitrogen and phosphorus and high fertility class with respect to potassium. Most of the area of Navagarh block was covered by LLM, LLH and LMH categories.

Key words : Geographic information system, Global positioning system, Nutrient mapping, Soil fertility status

How to cite this article : Devdas, Deepika, Srivastava, L.K. and Mishra, V.N. (2016).Mapping of nutrients status by geographic information system (GIS) in Navagarh block under Janjgir district in Chhattisgarh. *Asian J. Soil Sci.*, **11** (1) : 103-109 : **DOI : 10.15740/HAS/AJSS/11.1/103-109.**

Introduction

Chhattisgarh state lies between $17^0$46-$24^0$8 N latitude and $80^0$15-$84^0$24 E longitude. The total geographical area of the state is 136034.28 km^2 north to

south and 336 km from East to West with a total area of 1,35,194 sq. km. The use of plant nutrients in a balanced manner is the prime factor for efficient fertilizer programme. Balanced nutrient use ensures high production level and helps to maintain the soil health. Chhattisgarh state has four major soils type *i.e. Entisol, Inceptisol, Alfisol* and *Vertisol* and broadly comes under red and yellow soils group. Almost all soils are deficient in nitrogen and phosphorus and medium to high in potassium. Zinc deficiency is emerging and commonly observed in *Alfisol* and *Vertisol* of this region which can be grouped in to black soils.

Intensively cultivated soils are being depleted with available nutrients especially macro and micronutrients. Therefore, assessment of fertility status of soils that are being intensively cultivated with high yielding crops needs to be carried out. Soil testing is usually followed by collecting composite soil samples in the fields without geographic reference. The results of such soil testing are not useful for site specific recommendations and subsequent monitoring. Soil available nutrients status of an area using Global Positioning System (GPS) will help in formulating site specific balanced fertilizer recommendation and to understand the status of soil fertility spatially and temporally.

The modern geospatial technologies such as Remote Sensing (RS), Geographical Information System (GIS), Global Positioning System (GPS) and Information Technology (IT) offer immense potential for soil and water resources development and management. GIS is a potential tool used for easy access, retrieval and manipulation of voluminous data of natural resources which is difficult to handle manually. It facilitates manipulation of spatial and attributes data useful for handling multiple data of diverse origin. Several databases are available at global and national level which can be analysed and properly utilized for planning management of soil resources.

Study area :

Navagarh block is located at Janjgir-Champa district lying between 21.6 to 22.0° North latitude 82.3 to 82.2° East longitudes. In Navagarh block the normal rainfall is 1359.0 mm and average rainfall 1141.0. The region generally experiences hot, sub humid climate, having average rainfall of 1157.1 mm. The hottest and coolest months are May and December, respectively. The maximum temperature during the summer may exceed upto 49^0C and the minimum temperature often falls below 8^0C during winter season.

Resource and Research Methods

A suitable and represent soil sampling strategy is very important for evaluation fertility status. The area of whole agricultural land to be mapped was divided into small systematic grids of each village. The village level cadastral maps were obtained from land revenue department and suitable soil sampling spots were precisely by overlaying systematic grids. The exact positions of sampling spots (latitude and longitude) were obtained then the sample collected from the correct spot with help of global positioning system. The method of using these techniques for devising suitable soil sampling plan has been described (Oliver and Frog,1998; Polive and Aubert,1998). The application of soil sampling for spatial fertilizer recommendation is described recently by Grandzinski *et al*. (1998)

Sampling points were pre-determined across a field for a soil type under study. Samples were taken at fixed intervals systematically across a grid from each of 10 ha area. Within each of such sample points, five samples were randomly taken for further analysis, to represent the 10 hectares area or grid selected under the soil. Land System Maps published by Chhattisgarh Info. Tech. and Biotech. Promotion Society (CHIPS) and Indian Satellites Research Services (ISRO) in 2004-05 at the scale of 1:4000 have been used as the cadastral maps for conducting the field survey works. Prior to the actual fieldwork, tentative sampling sites were fixed on the cadastral maps. These sampling sites were set and distributed in such a way that all the agriculturally important land system units are proportionately represented.

Soil sampling points were determined according to the steps explained at para 3.3 above for each village cadastral map. Generally in each village, two to four types of soil were found. The area was surveyed in each village and sampling was done considering one soil sample from each of 10 hectare area should be taken. After sampling, the points were marked by GPS with latitude, longitude and altitude. The soil samples were collected from 15 cm depth with the help of soil stainless steel auger. The soil of experimental site was analyzed for the physico-chemical properties like pH, electrical conductivity, organic carbon and available nutrient (N, P, K, Fe, Cu, Zn and Mn).

Research Findings and Discussion

A study on soil pH (Table 1) revealed that the soil samples collected from the farmer's field were acidic to slight alkaline in reaction and pH ranged from 5.8 to 8 with an average of 6.24. Soil samples were collected from 47 villages in Navagarh block covering 1285 sites representing soils using Global Positioning System (GPS) such that from each 10 ha area represented one grid sample. Singh *et al*. (2009) reported that surface and subsurface soils were normal to slightly alkaline in reaction in the soils of district Ghazipur, Uttar Pradesh. Considering in Table 1 the soils having <5.0 as strongly acidic, 5.0 to 6.0 as moderately acidic, 6.1 to 6.5 as slightly acidic, neutral as 6.6 to 7.5 and slightly alkaline as 7.6 to 8.5. In general out of 1285 samples 21.24 per cent soils were found in moderately acidic, 69.1 per cent in slightly acidic, 8.48 per cent neutral and 1.16 per cent slightly alkaline in reaction (Table 1).

The data pertaining to the fertility status of Navagarh block are presented in Tables 2 to 5 and Fig. 1 to 7. *Inceptisols Alfisols and Vertisols*, the available nitrogen content varied between 87 to 388, 88 to 398 and 163 to 387 kg ha^{-1}, respectively. Available phosphorus (P_2O_5) content ranged from 1.60 to 25.98 , 1.61 to 25.72 and

Table 1 : Limits for the soil test values used for rating the soil

Classification for pH values				
Strongly acid	Moderately acid	Slightly acid	Neutral	Slightly alkaline
<5.0	5.0-6.0	6.1-6.5	6.6-7.5	7.6-8.5
Classification for total soluble salt content (EC as dS m^{-1})				
Normal	Low salinity	Medium salinity		High salinity
<1	1-2	2-3		>3
Nutrients	Low	Medium		High
O.C.(%)	<0.50	0.50-0.75		>0.75
(Macronutrients)				
N (kg ha^{-1})	<280	280-560		>560
P (kg ha^{-1})	<12.5	12.5-25		>25
K (kg ha^{-1})	<135	135-335		>335
(Micronutrients)	Deficient	Sufficient		High level
Fe (mg kg^{-1})	<4.50	>4.50		>9.00
Mn (mg kg^{-1})	<3.50	>3.50		>7.00
Cu (mg kg^{-1})	<0.20	>0.20		>0.40
Zn (mg kg^{-1})	<0.60	>0.60		>1.20

Table 2 : Status of pH, EC and OC in surface soil samples of Navagarh block

	pH	EC	OC
Inceptisols			
Mean	5.73	0.16	0.53
SD	± 0.55	± 0.08	± 0.09
Range	4.5-7.2	0.05-0.78	0.25-0.83
Alfisols			
Mean	6.2	0.25	0.58
SD	± 0.22	± 0.13	± 0.64
Range	5.8-7.3	0.04-0.98	0.29-0.88
Vertisols			
Mean	7.1	0.24	0.51
SD	± 0.51	± 0.03	± 0.09
Range	6.5-8	0.15-0.32	0.32-0.67

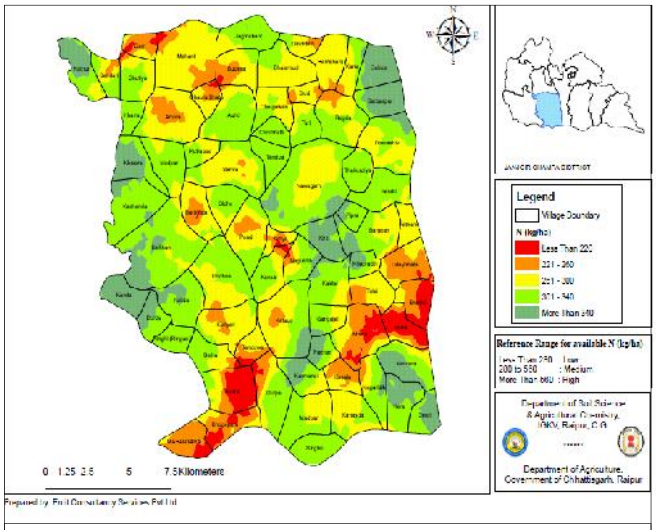

Fig. 1 : Status of available N (nitrogen) in soils of Nawagarh tehsil (Janjgir Champa, C.G.)

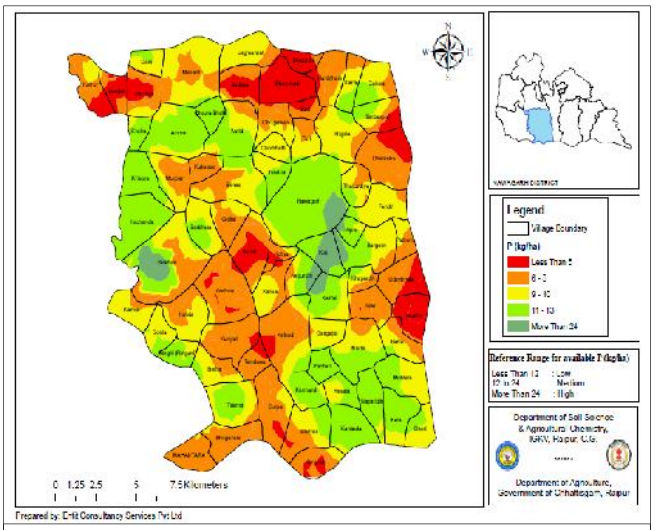

Fig. 2 : Status of available P (phosphorus) in soils of Nawagarh tehsil (Janjgir Champa, C.G.)

Table 3 : Status of major nutrients in surface soil samples of Navagarh block

	N	P	K
Inceptisols			
Mean	254.2	16.47	286.8
SD	± 66.9	± 5.89	± 94.1
Range	87.8-388.9	1.60-25.98	98.7-482.2
Alfisols			
Mean	265	7.18	264
SD	± 42.21	± 3.69	± 98.80
Range	88-398	1.61-25.72	88.14 -503
Vertisols			
Mean	264	11.02	345
SD	±52.49	±9.47	±88.66
Range	163-387	1.52 – 29.33	157- 473

Table 4 : Status of micro-nutrients in surface soil samples of Navagarh block

	Cu	Fe	Mn	Zn
Inceptisols				
Mean	2.13	26.52	31.57	0.90
SD	±1.78	±10.91	±14.59	±0.78
Range	0.16-10.84	3.24-51.42	0.32-64.80	0.16-5.40
Alfisols				
Mean	3.22	24.42	27.62	0.82
SD	±4.46	±12.36	±15.94	±0.53
Range	0.16-28.08	0.44-91.56	0.70-84.4	0.02-6.18
Vertisols				
Mean	3.54	10.41	20.74	0.77
SD	±1.18	±7.52	±7.33	±0.39
Range	1.25-5.69	2.24-33.38	10.36-33.34	0.32-1.98

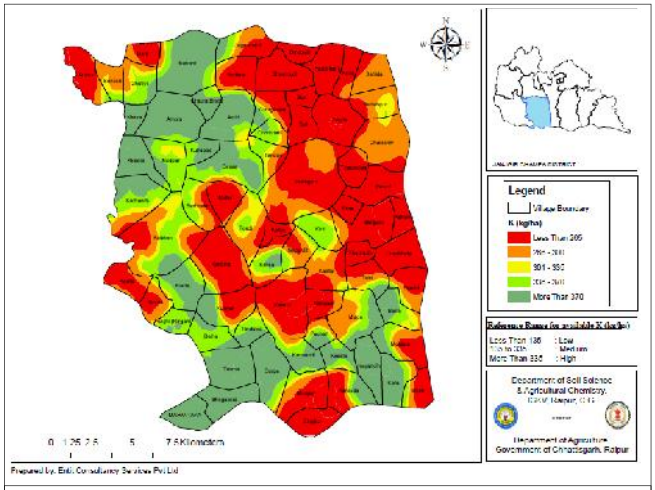

Fig. 3 : Status of available K (potassium) in soils of Nawagarh tehsil (Janjgir Champa, C.G.)

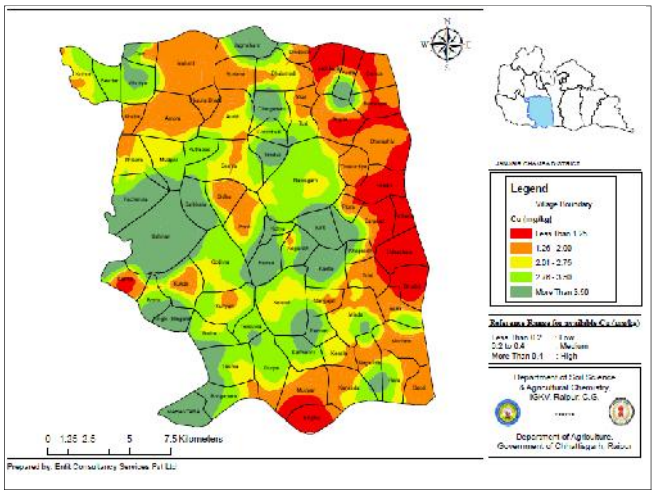

Fig. 4 : Status of available Cu (copper) in soils of Nawagarh tehsil (Janjgir Champa, C.G.)

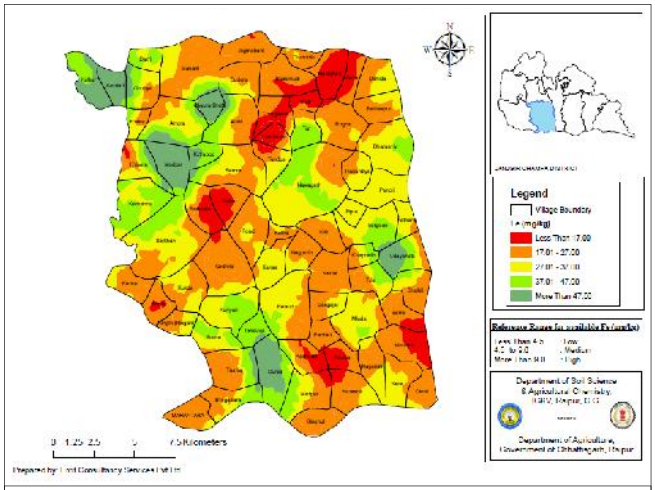

Fig. 5 : Status of available Fe (iron) in soils of Nawagarh tehsil (Janjgir Champa, C.G.)

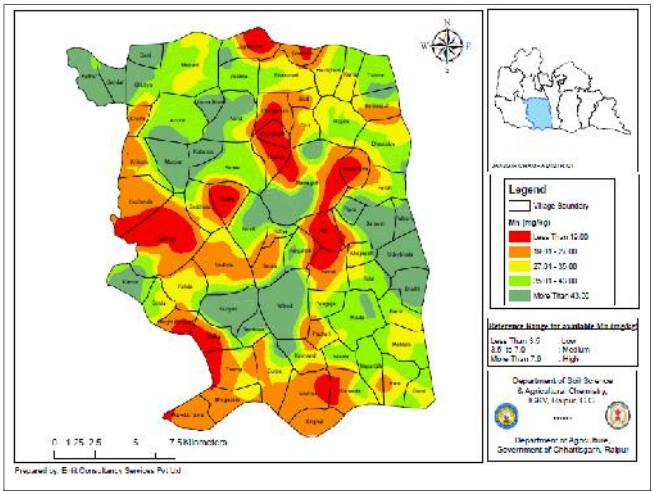

Fig. 6 : Status of available Mn (manganese) in soils of Nawagarh tehsil (Janjgir Champa, C.G.)

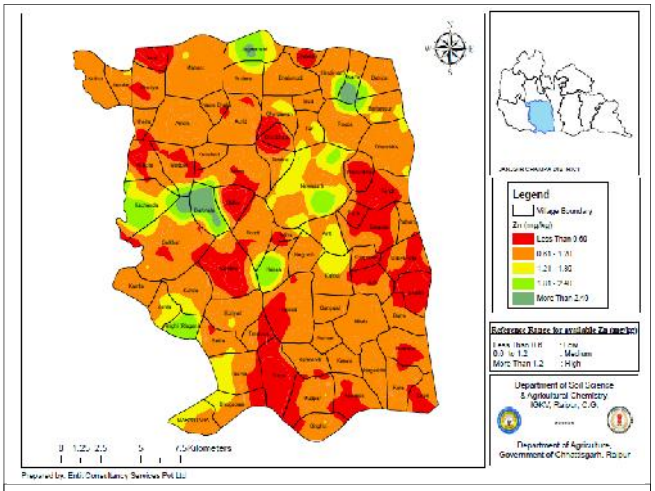

Fig. 7 : Status of available Zn (zinc) in soils of Nawagarh tehsil (Janjgir Champa, C.G.)

1.52 to 29.33 kg ha^{-1} and that of available potassium (K_2O) ranged from 98 to 482, 88 to 503 kg ha^{-1} and 157-473, respectively in *Inceptisols Alfisols and Vertisols*. Nagaraj (2001) and Ravikumar *et al*. (2007a) observed a similar trend of nutrient status in black soils of north Karnataka. The major proportion of the study area was low in organic carbon and remaining area was medium in organic carbon. Low organic carbon in the soil was due to low input of FYM and crop residues as well as rapid rate of decomposition due to high temperature. The organic matter degradation and removal taken place at faster rate coupled with low vegetation cover thereby leaving less changes of accumulation of organic matter in the soil. These observations are in accordance with Govindarajan and Datta (1968). The available nitrogen

content was low in major portion of the study area which might be due to low organic matter content in these soils. Only in about 8 villages , available nitrogen was medium. The variation in N content may be related to soil management, application of FYM and fertilizer to previous crop (Kumar, 2000). The total nitrogen content in the soils is dependent on temperature, rainfall and altitude. Another possible reason may also be due to low organic matter content in these areas due to low rainfall and low vegetation facilitate faster degradation and removal of organic matter leading to nitrogen deficiency. The medium nitrogen status in some area may be due to application of N fertilizer recommended for the crops. The available phosphorus content was low in major parts of the study area where as, it was medium in 44 villages of the study area. The available potassium content in major portion of the study area was in medium and high category. *Inceptisols Alfisols and Vertisols* were higher in available potassium status due to predominance of K rich micaceous and feldspars minerals in parent material. Similar results were observed by Ravikumar *et al*. (2007a). Major portion of area was under medium (71 villages) and high category (50 villages) of available potassium status in *Inceptisols Alfisols and Vertisols*, Adequate (medium or high) available K in these soils may be attributed to the prevalence of potassium-rich minerals like *Illite* and *Feldspars* (Sharma *et al.*, 2008).

Available Zn status in *Inceptisols Alfisols* and *Vertisols* soils was deficient to sufficient in the major portion of the study area. Since, the soils are alkaline and rich in $CaCO_3$, zinc may be precipitated as hydroxides and carbonates under alkaline pH range. Therefore, their solubility and mobility may be decreased resulting in reduced availability. Similar results were also reported by Vijaya *et al*. (2000) and Ravikumar *et al*. (2007a).

Inceptisols Alfisols and *Vertisols* most of the soil was high level category in available Fe status. High available Fe content in soils of Navagarh block might be due to its topography and cultivation of rice, which induced prolonged submergence coupled with reducing conditions. Majority of the soils were not deficient in Fe as the amount of iron required by crops is being released by iron bearing minerals in these soils. The soil pH had reverse effect on the availability of Fe content in soil.

Major portion of the study area was high and some area was under sufficient status of available copper). Raghupathi (1989) reported that available copper content in North Karnataka soils ranged from 0.32 to 84.4 mg kg^{-1}. Similar results were also observed by Ravikumar *et al*. (2007b).

In *Inceptisols Alfisols* and *Vertisols*, the available manganese was found to be high in almost 90 per cent of study area and sufficient and deficient in remaining fields, which may be due to neutral to low pH and nature of the parent material as reported by Prasad and Sahi (1989). Arora and Sekhon (1981) reported that high pH calcareous black soils coupled with semi-arid conditions decreases the availability of Mn by converting into unavailable forms (Mn++ converted Mn+++). high content of manganese due to high organic matter content was observed in Upper Krishna Command Area by Vijaya *et al*. (2000). From the study, it can be concluded that, soils of Navagarh village in northern transition zone of Karnataka were low in soil organic matter content. Available nitrogen and phosphorus were low to medium and available potassium were medium to high. Regarding available micronutrients, most of soil samples were found in sufficient levels of Fe, Mn and Cu but 32.21 per cent soil samples were deficient in Zn content. Soil organic matter available N and available P were important soil

Table 5 : Soil fertility assessment based on soil fertility index

Fertility class	No. of villages
Low-Low-Low (LLL)	3
Low-Low- Medium (LLM)	47
Low-Medium- Low (LML)	1
Medium - Medium – High (MMH)	1
Medium- Low- Medium (MLM)	2
Medium - Medium –Medium (MMM)	5
Low-Low-High (LLH)	29
Low- Medium - High (LMH)	20
Low-Medium-Medium (LMM)	17
Total	125

fertility constraints indicating their immediate attention for sustained crop production. The deficient OC may be replenished to avoid the crops suffering from their deficiency and for optimum utilization of other nutrients.

Based on the criteria given in Table 5 the overall soils (*Inceptisols Alfisols and Vertisols*) of Navagarh block have been characterized into nine soil fertility categories (available N, P and K), *viz.*, Low-Low-Low (LLL), Low- Low - Medium (LLM), Low-Medium-Low (LML), Medium - Medium - Low (MML),), Medium - Medium - Medium (MMM), Low - Low – High (LLH), Medium - Low- Medium (MLM) Low-Medium-High (LMH) and Low-Medium-Medium (LMM). Most of the area of Navagarh block was covered by LLM, LLH and LMH categories.

Literature Cited

Arora, C.L. and Sekhon, G.S. (1981). Influence of soil characters on DTPA extractable micronutrients cations in some soil series of Punjab. *J. Indian Soc. Soil Sci.*, **29** : 453-462.

Govindarajan, S.V. and Datta, Biswas N.R. (1968). Characterization of certain soils in the sub- tropical humid zone in the south eastern part of Indian soils of Muchkand basin. J. *Indian Soc. Soil Sci.*, **16 :** 117-186.

Grandzinski, M., Vanoverstrasten, M., Schroder, D. and Filch, R. (1998). Using maps and local calculation method for spatially variable fertilizer recommendation. Proc. No. 422, Int. Fert. Sok. U.K.

Kumar, Ashok S. (2000). Studies on soil aggregation in Vertisols of North Karnataka. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, KARNATAKA (INDIA).

Nagaraj, K. (2001). Studies on soils and their interpretative grouping under Distributary No. 18 in Malaprabha Command Area. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, KARNATAKA (INDIA).

Oliver, M.A. and Frog, Brook Z.L. (1998). Sampling to estimate soil neutrients for precision agriculture. The Int. Fert. Soc. Proceeding No. 417. PO Box 4, York YO32 5 YS. UK.

Polive, H. and Aubert, P.S. (1998). Remote sensing for precision soil and crop management. Proc No. 420 Int. Fert. Soc. U.K.

Prasad, S.N. and Sahi, B.P. (1989). Distribution of manganese in relation to soil properties in some typical soil profiles. *J. Indian Soc. Soil Sci.*, **37**(3) : 567-570.

Raghupathi, H.B. (1989). Investigation on soil copper and crop response in selected soils of Karnataka. M.Sc. (Ag.) Thesis, University of Agricultural Sciences, Dharwad, KARNATAKA (INDIA).

Ravikumar, M.A., Patil, P.L. and Dasog, G.S. (2007a). Mapping of nutrients status of 48A distributary of Malaprabha Right Bank Command of Karnataka by GIS Technique. I- Major nutrients. *Karnataka J. Agric. Sci*., **20**(4): 735-737.

Ravikumar, M.A., Patil, P.L. and Dasog, G.S. (2007b). Mapping of nutrients status of 48A distributary of Malaprabha Right Bank Command of Karnataka by GIS Technique. II Micro nutrients. *Karnataka J. Agric. Sci.*, **20**(4): 738-740

Sharma, P.K., Sood, A., Setia, R.K., Tur, N.S., Mehra, D. and Singh, H. (2008). Mapping of macronutrients in soils of Amritsar district (Punjab) A GIS approach. *J. Indian Soc. Soil Sci.*, **56** (1): 34-41.

Singh, V.S., Agrawal, H.P. and Prasad, S. (2009). Distribution of DTPA-extractable micronutrients in the soils of district Ghazipur, Uttar Pradesh. *J. Indian Soc. Soil Sci.*, **57** (3) : 370 – 372.

Vijaya, Sekhar R., Vittal, Kuligod B., Basavaraj, P.K., Dasog, G.S. and Salimath, S.B. (2000). Studies on micronutrient status in important black soil series of UKP command, Karnataka. *Andhra Agril. J.*, **47**: 141-143.